XIII. *On the Errors in the Course of Vessels, occasioned by Local Attraction; with some Remarks on the recent Loss of His Majesty's ship Thetis.* By Peter Barlow, *Esq. F.R.S. Cor. Mem. of the Inst. France, Imp. Acad. Sciences St. Petersburgh, Acad. Sciences Brussels, &c. &c.*

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On presenting the following remarks to the attention of the Royal Society, I feel it necessary, first, to apologize for their not possessing that degree of scientific novelty which is generally expected in such communications,—and secondly, that in enforcing my argument, I may perhaps seem to give more value to my own investigations than is consistent with good taste. I must, however, either in some measure do this, or leave the evil untouched, which I feel it my duty to endeavour to remove; and therefore, trusting to a liberal interpretation of my motives, I shall state without reserve such facts as appear necessary to establish the object I have in view, and it is hoped the want of novelty will be compensated by the importance of the subject under consideration.

That a ship's compass is subject to a deviation from its true direction in consequence of the attraction of the iron used in the construction and appointments of the vessel, is now too generally admitted to require any argument, although I believe there may be still some few officers who are sceptical on this point; I have at least been seriously assured by one of rank and long standing, "that there certainly was no local attraction when he was at sea." Now there is really more in this observation than one would imagine, for there can be no question that forty years back the error arising from this disturbing force was very inconsiderable to what it is at present; every year in fact increasing the amount, and rendering a correction of the error more and more necessary. This increase is occasioned by the immense quantity of iron now employed in the construction of a ship of war and its appointments. At the period above

alluded to, iron ballast and iron tanks were perhaps scarcely known; now we have, besides these, iron knees, iron cables, and above all iron capstans, besides various other articles of the same material, which together form such an attracting mass, that if we cannot allow that there was no local attraction forty years back, we must at least admit that it was certainly then very inconsiderable to what it is at present, and that navigation by compass was at that time comparatively on equal terms with nautical astronomy; but since that period, the errors of the one have been gradually removed by improvements in instruments, the introduction of chronometers, and the correction of astronomical tables and data, whereas the compass still remains the same uncouth machine, and the disturbing forces to which it is exposed have been increased in, perhaps, a fourfold proportion. At all events the disturbing force is now considerable, and the deflection it causes in the needle, under some circumstances, very great; and as this effect is perpetually varying as the course of the vessel is changed, as it is also as she changes her latitude, though the course should remain the same, a constant attention to the amount of this error seems to be indispensable, at least in those circumstances where the whole safety of the vessel is dependent on the certainty of the courses steered, which is in fact always the case in a dark night, and when land is near.

It is almost impossible to give a very popular idea of the direction and amount of this deflecting force. It may however be stated, that in this latitude, and in all those northern latitudes where the dip is considerable, the greatest deflections take place, on an east or on a west course, diminishing both ways to the north and south, where it vanishes; and in all these cases the direction of the deflection is always to the right or left of a person, looking forward in the vessel, accordingly as the course of the vessel is to the right or left, that is to the east or west of the meridian, and it is exactly the reverse in a high southern latitude or with a considerable southern dip. But as we approach the equator, where the dip is small, the deflections at the east and west points vanish, and we have then four points of greatest attraction, viz. the N.E., N.W., S.E., and S.W., the direction of the deflection changing as we pass through the N., S., E., and West points; but the deflection at its maximum is much less in these latitudes than in those where the dip is more considerable, all other things being the same.

These rules, which are given upon the supposition that the compass is situated in its usual place, aft in the vessel, will furnish a general idea of the direction of the deflection. With regard to the actual amount, it is of course different in different vessels, varying in these latitudes from 5° to 12° or 14° with an easterly or westerly course; which become greater as we increase our latitude, but diminish (without however vanishing) at the equator, whence it again increases as we approach the southern pole.

The following are some results, several of which I have assisted in taking; they rest, as will be seen, on the best authorities, and will give a good general idea of the maximum amount.

Ship.	Commander.	Place.	Local Attraction.
			° ′
Conway . .	Captain Basil Hall . .	Portsmouth . .	4 32
Leven . .	Captain Owen	Northfleet . .	6 7
Baracouter .	Captain Cutfield . . .	Northfleet . .	14 30
Hecla . .	Captain Sir E. Parry .	Northfleet . .	7 27
Fury . . .	Captain Hopner . . .	Northfleet . .	6 22
Griper . .	Captain Clavering . .	Nore	13 36
Adventure .	Captain King	Plymouth . .	7 48
Gloucester .	Captain Stuart . . .	Channel . . .	9 30

Giving a mean of 8° 44′ at the east and west points in these latitudes.

The latter observation by Captain Stuart is from the remark-book of the Gloucester, and from which I beg to give the following extract:

"1830. 30th August. From not having had a favourable opportunity of ascertaining the ship's magnetism or local attraction in steering down the British Channel, I only allowed the true variation as found, but observed the ship was invariably drawn to the southward of her intended place, notwithstanding the greatest care being taken in steering her. But on taking an amplitude of the sun at setting on the 1st September, I found the variation to be 34° W. (when the ship's head was west), which difference from the true variation in the Channel 24° 30′ W. will account for the ship being so drawn to the southward of her intended track."

It would be quite superfluous to give further evidence of the existence of

this disturbing power; and little, I conceive, need be said to show how much such deviations from the estimated course of a vessel, in channels and narrow seas, are calculated to lead to the most disastrous events. To take the last case, for example, where the deviation is 9° 30′, and for the deviation in miles the general expression (dist. × 2 sin $\frac{1}{2}$ deviation), we shall find that after running ten miles, the vessel would be more than a mile and a half to the southward of her reckoning; in a distance of twenty miles, three miles and a quarter to the southward; in thirty miles, five miles to the southward, and so on as the distance increases.

Now it requires no knowledge of navigation to estimate the fatal consequences that might attend such an error in a narrow channel and in a dark night, if it were wholly unknown or disregarded. We see also how very easy it is, after an accident has occurred, to imagine a current (unknown of course to exist before), to account for the disaster. The Gloucester, for example, in the above instance was constantly "drawn to the southward;" and this might have been set down to the effect of a current, had it not been proved to be local attraction.

That a ship is sometimes involved in an unknown or unusual current, which may lead her into an error of reckoning, no one can for a moment deny; but I do at the same time maintain, that unless a proper attention be paid to the local attraction, a vessel is as it were in a perpetual current, setting sometimes in one direction, and sometimes in another, sufficient to baffle the most experienced pilot; and I further maintain, that science and humanity both require, before we admit the plea of unknown currents to explain the cause of every disaster, that it be sufficiently ascertained how far allowance has been made, or a correction obtained for that current, which it is now well known a vessel carries with her through every league of her voyage.

Let us now turn to the late melancholy wreck of His Majesty's ship Thetis. It appears from the account given of this disaster in the United Service Journal, that "the Thetis sailed from Rio Janeiro on the 4th of December, with a million of dollars on board, besides other treasure, and every prospect of a fine passage, stretching away to the S.E. The next day, the wind coming rather favourable, they tacked, thinking themselves clear of land; and so confident were they, that the top-mast studding sails were ordered to be set, the ship run-

ning at the rate of nine knots; and the first intimation they had of being near land, was the jib-boom striking against a high perpendicular cliff, when the bowsprit broke short off, the shock sending all three masts over the side;" and thus in a moment perished twenty-five valuable lives, and a fine vessel, with her cargo, worth nearly a quarter of a million sterling.

Here then we have a case of a ship leaving port one day, with every prospect of a fine passage, which had so far lost her reckoning on the evening of the next day, as to be wrecked on a rock not more than seventy miles from her point of departure, which was supposed to be some miles to her west.

I have no desire to prejudge the cause of this unfortunate misreckoning; I wish only the true cause should be ascertained. In the letter of the commander of the Thetis to the admiral on the station, he says, that "from all the precautionary measures taken, nothing but the strongest currents, and the thick hazy weather, and hard rain, can be pleaded in extenuation."

I most sincerely hope that amongst "the precautionary measures taken," that of correcting or making proper allowance for the local attraction was included; for I have no hesitation in asserting, if such precaution was not taken, that this omission would be quite sufficient to account for the accident. It is obvious from the general principles which I have stated in the preceding part of this paper, that at Rio, where the dip of the needle is about 22° south, (the course steered on the 4th of December having been S.E., and on the 5th of December necessarily somewhere between the east and north,) the local attraction would be constantly drawing the vessel over to the westward, and there can be no question that her being more to the westward than her reckoning, was, from whatever source it might have proceeded, the cause of the disastrous event.

Without therefore in any way prejudging the case, I have only to express a hope that some inquiry may be made, to ascertain whether any and what allowance or correction was made for the local attraction of the vessel.

It is impossible now, if the local attraction of the Thetis has not been before taken, to know its amount; but we can ascertain, at least approximatively, what would have been the deflection of the Gloucester under similar circumstances; and as the amount of attraction in this vessel is nearly the mean of all those I have given in a former page, it may be interesting to see the result.

It has been stated that the maximum attraction or deflection is much less (all other things being the same) with a small dip than with a large one; the proportion being, "that the tangents of the angles of deflections are inversely as the cosines of the dip:" now, the dip at Rio Janeiro being about 22°, and in London $69\frac{1}{2}°$, we have

$$\cos 22° : \cos 69\tfrac{1}{2}° :: \tan 9° 30' : \tan 3° 33'.$$

That is, the Gloucester leaving Rio under similar circumstances to the Thetis, would on any course about the S.E. or N.E. (the former being stated as the course of the latter vessel on the 4th, and the other her probable course after tacking on the 5th of December), be constantly deflected about $3\frac{1}{2}°$* out of her supposed course, and as the sine of 3° 33′ is about $\frac{1}{16}$th part of the radius, it is obvious, taking only the error due to the 5th of December, and reckoning the distance run at eighty miles, that the ship would pass five miles nearer to Cape Frio than her reckoning, an error quite sufficient to account for the fatal catastrophe which has occurred to the Thetis; for it appears that a distance of only so many fathoms would have nearly carried her clear of the land. I do not include the error due to the first day, because its tendency would only be to carry the vessel to the southward about the same quantity, which of itself could have produced no evil.

After all, let it be remembered that this is a supposititious case, and that my object in stating it is merely to show what might happen if the deflection from local attraction were disregarded, and thereby to prove the propriety and necessity of ascertaining whether in the case of the Thetis, and in all similar cases, the proper correction was made, before the apology of currents can be admitted.

I urge this the more particularly, because I fear this source of error is too much disregarded, and as I think it probable that in the several investigations which have been held to inquire into cases of vessels lost in a similar way for the last ten years, since I have been interested on this subject, no question has been asked whether or not the error of the compass had been corrected; and thus vessel after vessel is lost, and current after current is imagined to ac-

* I say about $3\frac{1}{2}°$, because much depends upon the direction of the centre of attraction in the vessel.

count for the loss, while an actually existing and known cause is allowed to remain uncorrected and disregarded.

That the remedy for this evil, which I have been so fortunate as to discover, is simple and universal, is, I believe, generally admitted; indeed, after being submitted to trial by two of our most scientific officers from 57° south latitude to 80° north latitude, and having been found to be effective to the most extreme point, it is impossible that any doubt should remain on that head.

It must be, therefore, that the error itself is disregarded, and it would consequently be rendering an essential service to the navy, when any loss is sustained from neglecting this necessary precaution, that it should be traced to its proper source; and it is with this view that I have drawn together these few remarks. If I overrate the importance of the error or the value of the remedy, my apology must be the opinions which have been given on the subject by many distinguished naval commanders, both English and foreign, and the high marks of approbation with which my investigations have been acknowledged by the Royal Society, and other learned societies of Europe. To which I may also add my anxiety, that where science can be brought to facilitate the progress of navigation, and to contribute to its security, it may not be allowed to be neglected in the British navy.